natural gas - auto fuel
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NATURAL GAS

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TABLE OF CONTENTS

Switching to Natural Gas	3
Finding and Choosing a Conversion Contractor and Refuelling Stations	7
Components of an NGV Conversion	11
Routine Operation of NGV Vehicles	17
Fleet Management	21
Regulations and Standards	23

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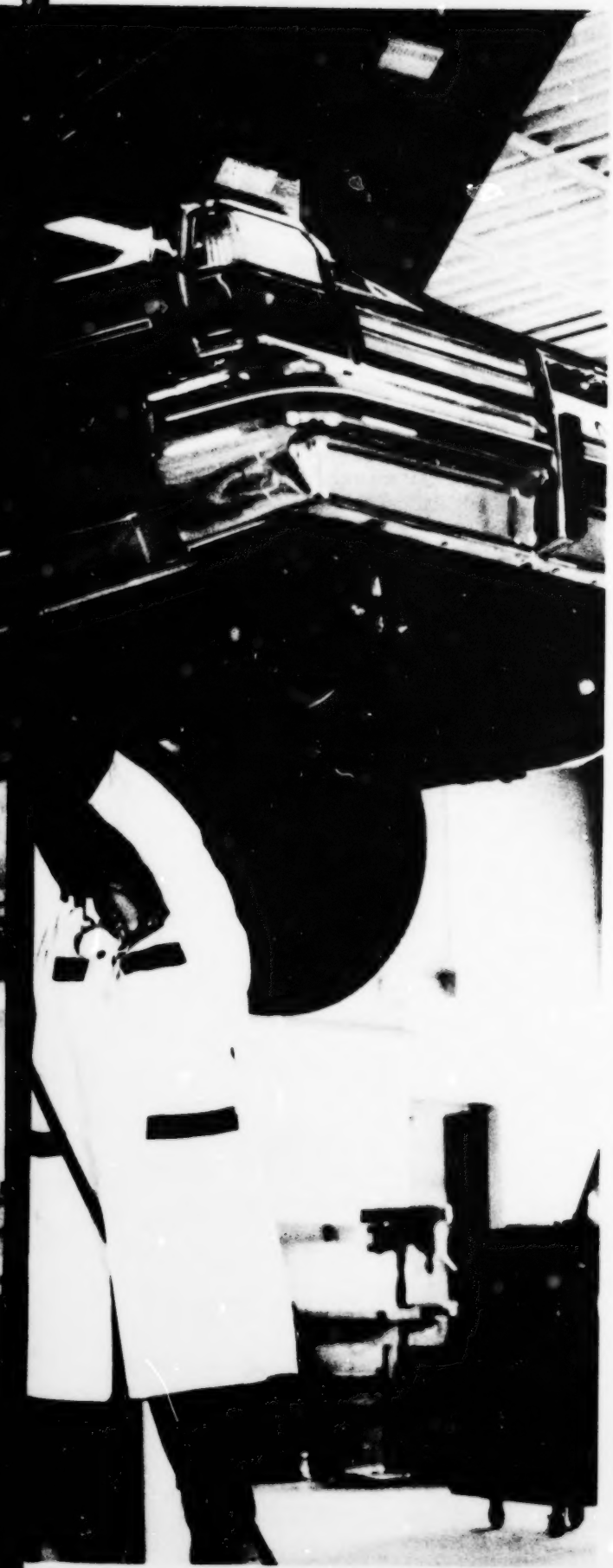


SWITCHING TO NATURAL GAS

Natural Gas (NG) is a fuel in abundant supply in Canada. Large proven reserves of NG in western Canada are capable of supply well in excess of current domestic demand. This situation is expected to continue for some time as new exploration and development activities result in increases in proven reserves. This fuel is secure and is not subject to supply and price disruptions as is imported crude oil.

NG from the wellhead is processed before its distribution to remove undesirable sulphur compounds and high-value components used in the chemical industry, such as ethane. The majority of Canada's propane comes from the processing of NG. The resulting gas is controlled to a standard specification containing at least 95% methane. NG is odorless, but for safety, a strong odorant is added to the fuel so that it can be easily detected.

NG has been used as a transportation fuel for at least 40 years in Italy, where more than 300 000 vehicles are powered by natural gas. New Zealand has launched a major drive to convert 200 000 vehicles to NG by 1990. In Canada, NG has been actively promoted as a transportation fuel only over the last several years. Considerable interest has been shown in the fuel because it can reduce operating costs and, technically, is a high-quality transportation fuel.

The characteristics of NG make it an excellent automotive fuel: it has a higher octane rating than gasoline; it is clean burning, usually with lower hydrocarbon and carbon monoxide emissions than gasoline; and it enters the intake manifold as a dry gas, thereby ensuring good fuel distribution to all cylinders. Its combustion characteristics are different from gasoline: like most gaseous fuels, NG requires more spark energy to ignite and spark advance modifications to achieve good performance.

NG is normally stored in compressed form on a vehicle. Natural gas for vehicles (NGV) is stored at 20 680 kPa (3000 psi).

Because the equivalent driving range with NGV is less than that for gasoline with the same fuel storage volume, and since the NGV fuel distribution network is not yet established throughout the province, converted vehicles normally operate on both gasoline and NGV (dual fuel). It is therefore important that a converted engine operate satisfactorily on both fuels — gasoline and NGV — even though the two fuels have different characteristics.

NGV enters the cylinder as a dry gas comprising about 10% of the gas-air mixture. In contrast, gasoline normally exists in the form of vapour droplets during the intake stroke and contains the same energy in less volume, with a higher proportion of the mixture being in the form of air. The greater displacement of the air by NGV and its slower flame speed, which may produce lower peak cylinder pressures, results in a loss of maximum power of 10 to 15%. The driver will only be aware of a vehicle which drives more smoothly on NGV and, unless he is carrying heavy loads, will probably not be aware of the power loss.

Economics of Switching

The cost of converting a typical vehicle, including parts and labour and two 40 to 60 L steel storage tanks, is approximately $2800. The cost of converting a larger vehicle, where more on-board fuel storage may be required, will be higher.

If the vehicle is converted within 30 days of its purchase, it qualifies for a rebate of the 7% provincial sales tax, which represents a savings of $980 on a $14,000 vehicle. In addition, the federal government, through its Natural Gas Vehicle Program, will provide a $500 taxable grant toward the cost of conversion. The three provincial gas utilities may also provide grants or funding, and vehicle owners should contact the local office of the utility to determine the availability of assistance at the time of conversion.

NGV currently retails at 35 to 45¢/kg throughout the province, depending on the location. How this cost compares with gasoline depends on the type and size of engine. It also depends on the time of year because gasoline tends to give somewhat poorer performance in the winter, whereas NGV is less sensitive to seasonal differences. On a straight energy basis, 1 kg of NGV is equivalent to about 1.6 L of gasoline and 2.1 L of propane. Thus, NGV costs about 22 to 28¢/L equivalent of gasoline and about 19 to 21¢/L equivalent of propane.

The fuel cost savings from using natural gas rather than gasoline will vary depending on the price of gasoline. When gasoline is at 50 to 53¢/L, a vehicle operator can save about 50% in fuel costs with NGV. With the price of gasoline in the low forties, the saving is less. While it is difficult to estimate future gasoline prices with any degree of accuracy, it is likely that the price will not increase in the short term. On the other hand, with a large surplus of NG in Canada, the price per kilogram is not expected to increase and may, in fact, decrease and will remain price competitive with gasoline for many years.

The pay-back period on the conversion investment will depend on the annual fuel consumption. For example, if a vehicle travels 30 000 km/year at a fuel efficiency of 18 L/100 km, 5400 L of gasoline would be consumed annually. With gasoline at 43¢/L, $940 would be saved annually using natural gas.

However, gasoline may still be used for some trips, such as out-of-town journeys or on occasions when it is not convenient to refuel with NGV. If vehicles operate 85% of the time on NGV, fuel costs will be reduced by about $800 a year.

Using the example of a $14,000 automobile with a $2,800 conversion cost, the net cost of conversion would be $1,320 ($2,800 less the 7% tax rebate if the conversion is completed within 30 days of purchase, and less the $500 federal grant). At $800 per year fuel savings, this would pay back the net conversion cost in one year and 8 months.

Fuel cost savings and pay-back periods can be calculated directly by the following steps.

1. Determine fuel efficiency on gasoline (FE_G) in L/100 km.

2. Calculate annual gasoline consumption (GCon):
   Annual kilometres x FE_G

3. Calculate annual gasoline costs (GCos):
   GCon x price/L

4. Calculate annual equivalent NGV consumption (NGVCon):
   GCon ÷ 1.6 kg

5. Calculate annual NGV cost (NGVCos):
   NGVCon x price/kg

6. Calculate annual fuel cost saving (GCos — NGVCos).

7. Adjust annual fuel cost savings for less than complete substitution of gasoline by NGV:
   (GCos — NGVCos) x % Substitution.

8. Calculate pay-back period (years):

$$\frac{\text{Net Conversion Cost}}{\text{(CGos — NGVCos) x \% Substitution}}$$

An example of the pay-back calculation is provided on Page 5.

Pay-back Calculation Example:

Conversion of a new $14,000 vehicle, eligible for the $500 federal grant and $980 provincial sales tax rebate — total conversion cost $2,800; net conversion cost $1,320.

Annual distance travelled — 30 000 km
— 85% urban travel, on NGV
— 15% inter-city travel, on gasoline

Gasoline cost — $0.43/L

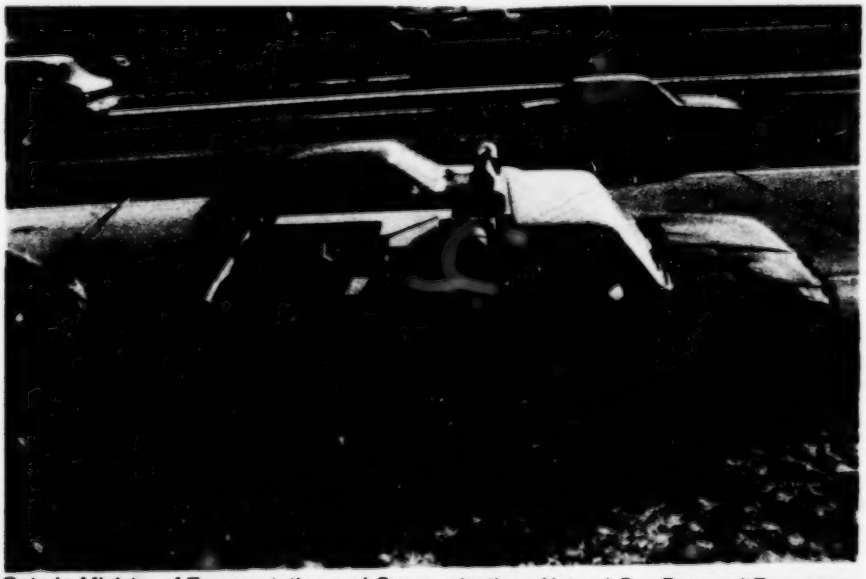
NGV cost — $0.41/kg

1. Fuel efficiency on gasoline — 18 L/100 km
2. Annual gasoline consumption — 30 000 x 18/100 = 5400 L
3. Annual gasoline cost — 5400 x $0.43 = $2,322
4. Annual equivalent NGV consumption — 5400/1.6 = 3375 kg
5. Annual NGV cost — 3375 x $0.41 = $1,384
6. Annual fuel cost saving — $2,322 - $1,384 = $938
7. Adjusted fuel cost saving — $938 x 0.85 = $797
8. Pay-back period on net conversion cost — $1,320/$797 = 1.7 years

After 1.7 years, the investment in conversion costs will be recovered. For the remaining life of the vehicle, the owner will save about $800/year using natural gas. When the vehicle is taken out of service at the end of its life span, the conversion equipment, which has a life of 15 to 20 years, can be removed and installed on the replacement vehicle for mainly the cost of labour. Hence, the pay-back period on the replacement vehicle will be considerably shorter than 1.7 years.

Gas Utility Services

Consumers' Gas, Union Gas and ICG Utilities (Ontario) Ltd. offer technical services to individual vehicle owners or to fleets to ensure the proper introduction of NGV into service. For fleets that are large enough to operate an on-site NG compressor, the utilities will provide assistance in doing financial analysis and in the writing of specifications for the compressor. Inquiries for this assistance can be made by contacting the local gas utility office.



Ontario Ministry of Transportation and Communications Natural Gas-Powered Emergency Patrol Vehicle

FINDING AND CHOOSING A CONVERSION CONTRACTOR AND REFUELLING STATION

Sources of Assistance

The following is a list of agencies who will be able to supply information on locating a conversion centre or a refuelling station and who can provide guidance if required:

Fuels Safety Branch
Ministry of Consumer and Commercial Relations
4th Floor, Shipp Centre
3300 Bloor Street West
Toronto, Ontario
M8X 2X2

(416) 239-2948

Canadian Gas Association
55 Scarsdale Road
Don Mills, Ontario
M3B 2R3

(416) 447-6465

The natural gas utility for your area (consult your telephone book):
Consumers' Gas
Union Gas
ICG Utilities (Ontario) Ltd.

Transportation Energy Management Program (TEMP)
Ministry of Transportation and Communications
1201 Wilson Avenue
Room 324, Central Building
Downsview, Ontario M3M 1J8
(416) 248-7296

Ministry of Energy
56 Wellesley Street, West
Toronto, Ontario, M7A 2B7
(416) 965-2984

Conversion Contractors

There are several NGV conversion contractors and the number will grow over time. The Fuels Safety Branch of the Ministry of Consumer and Commercial Relations maintains a list of licensed contractors; however, it cannot recommend a specific contractor. If possible, seek advice from a friend or colleague who has had a vehicle or vehicles converted and is satisfied with the results. The availability of parts and service and the warranty coverage offered are also important considerations.

The primary responsibility of the conversion contractor is to install the appropriate equipment to allow the vehicle to perform well on both fuels. The characteristics of a good NGV conversion are discussed later, but the key items of conversion include:

- *Ignition Timing:* The spark advance timing has to be adjustable to accommodate gasoline (85 to 90 octane) and NG (115 octane). This is normally accomplished electronically with a dual-curve ignition system.
- *Carburetor/Mixer:* The NG mixer is placed on top of the gasoline carburetor or in the cold air inlet tube to allow operation on either fuel.
- *Pressure Regulator:* The pressure of the stored NGV has to be reduced in stages to close to atmospheric pressure prior to mixing with air.
- *Storage Cylinders:* Since NGV takes up about four times as much space as the equivalent amount of gasoline and since the gasoline system is usually retained, fitting the storage cylinders to use the available space efficiently is very important.

The contractor must have certified personnel who are trained and experienced in NGV conversions. Community colleges offer formal NGV installation training programs. Knowing the characteristics of potential vehicles is important in terms of advising which vehicles will be suitable for NGV conversion.

As an alternative, if a fleet is involved, the fleet manager may wish to train some certified mechanics to undertake the conversions in-house, probably with the assistance of a conversion contractor for the first few.

Availability of Parts and Services

NGV systems are generally reliable and are no more likely to fail than the regular components of a standard automobile. However, mechanical components of any type can malfunction, and if this occurs, parts and service must be available. Parts availability for each of the conversion components should be checked. Also, make sure that service personnel are available who can repair a system or install the required new parts. It is a good idea for fleet operators to visit the contractors' shops and inspect their parts supply and service capabilities.

Spare parts shop

Warranty Coverage

A supplier should offer a warranty for all components of the system which he installs. Generally, such a warranty will be for 12 months from the time of installation on parts and up to 90 days on labour. The warranties offered by different companies should be compared.

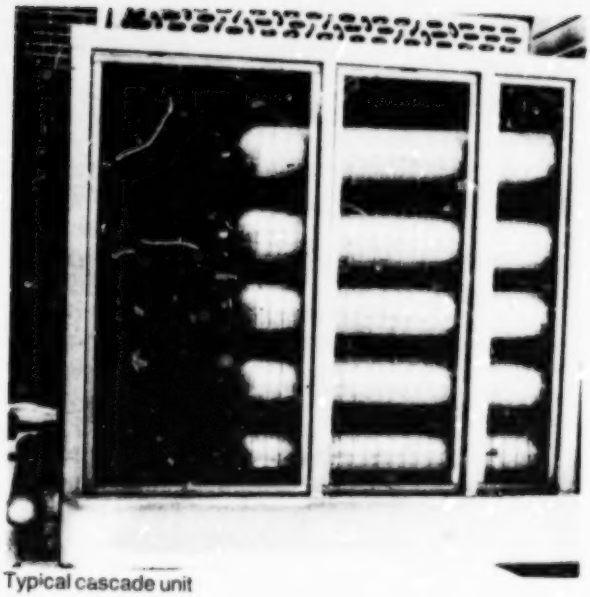
Each vehicle manufacturer has its own policies on the maintenance of warranties if new vehicles are being converted. To avoid any possible dispute later, the policy for the specific make and model of the vehicle being purchased should be determined from the dealer. Before entering in to a conversion contract, confirm that the manufacturer will stand behind the new vehicle warranty after the vehicle has been converted.

Refuelling

If only one or a small number of vehicles are converted, they will be refilled at a public NGV refuelling station. The number of stations is increasing at this time. Information on existing stations can be obtained from either the vehicle conversion company or the local natural gas utility. The Fuels Safety Branch will also have current information on existing stations and on stations for which approvals are being sought.

Fleet operators planning to convert a fleet of vehicles may wish to consider having their own refuelling facilities. The key items determining the cost of such facilities will be the amount of fuel required and the time available for refuelling. Slow- and fast-fill refuelling is possible, and the choice can significantly affect the size and cost of the compressor facility.

Slow-fill installation



Typical cascade unit

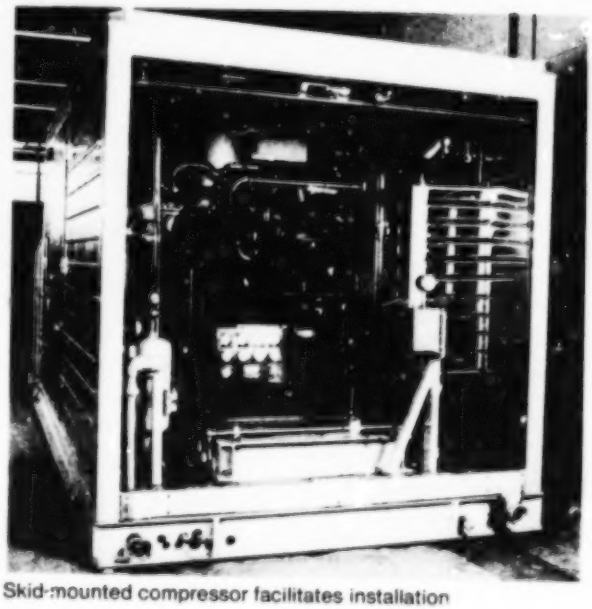
The lowest cost solution may occur if vehicles can be slow-filled overnight, with a compressor operating for eight to 12 hours to directly refuel the vehicle cylinders. However, fleets consisting of vehicles such as taxis, which have to be filled fairly rapidly during the day as well as overnight, may require a fast-fill or a combined slow- and fast-fill capability.

A fast-filling system using only a compressor without storage would require an impractically large compressor to provide fuel at the peak demand rate. Hence, the compressor operates in conjunction with storage in what is known as a cascade. A cascade is usually arranged in at least three banks of cylinders, with the cylinders in any one bank manifolded together so that each bank acts as one large container. The banks are controlled by automatic switching valves.

The cascade banks are initially filled with NGV in sequence by the compressor to the normal operating pressure of the system. The highest pressure bank is refilled first ("Bank 1"), followed by successively lower pressure banks ("Bank 2," "Bank 3," etc.). This sequence is called "priority fill."

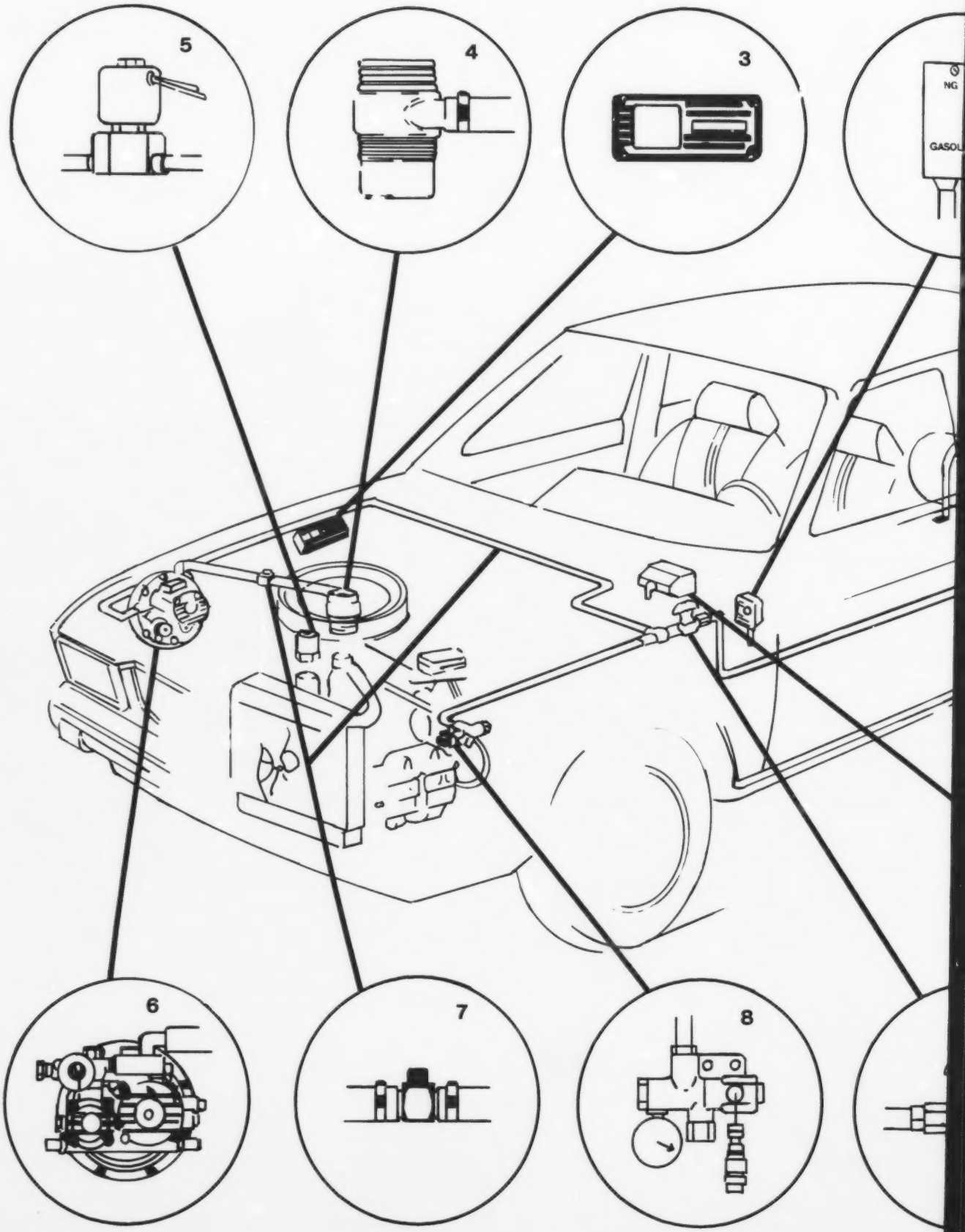
Vehicles can then be fuelled from the cascade, beginning with Bank 3 (for a three-bank cascade). At the completion of the last vehicle fill, the compressor will continue running, refuelling the cascade in the priority fill sequence.

A single compressor with cascade can be used to fast-fill vehicles during the day and slow-fill at night, if desired.



Skid-mounted compressor facilitates installation

Such refuelling systems, whether slow- or fast-fill or both, must be designed and installed with the necessary valves, protective fencing, and safety systems, in accordance with provincial and municipal requirements. The names of firms who can supply compressors and install the necessary systems may be obtained from the Pressure Vessels Safety Branch of the Ministry of Consumer and Commercial Relations or from the local gas utility.


5
4
3
NG
GASOL
6
7
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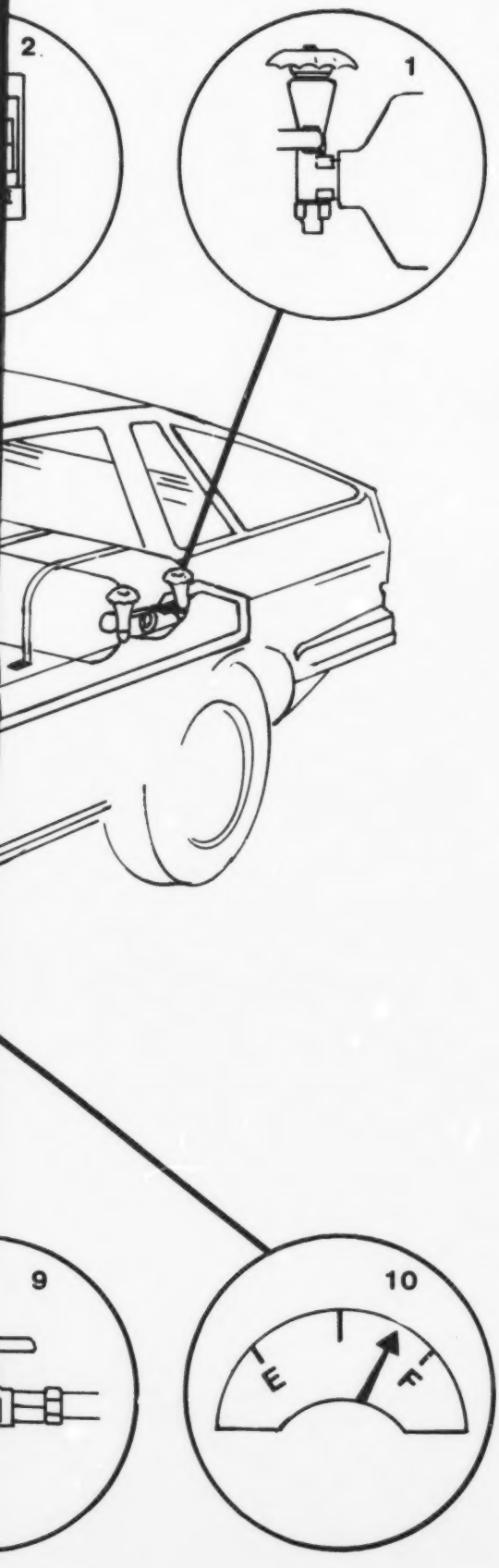
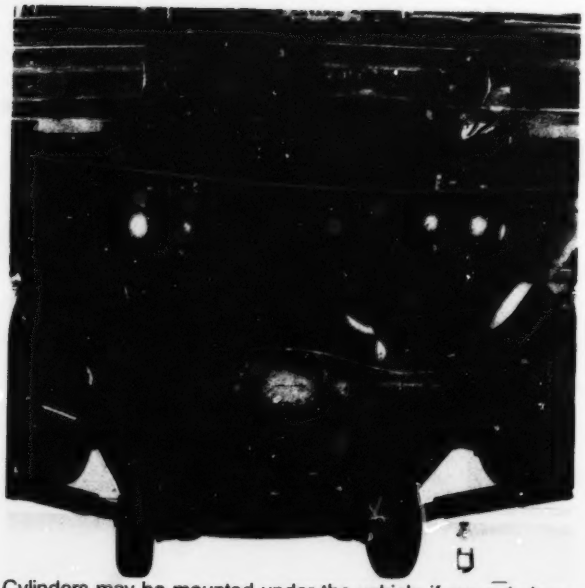


COMPONENTS OF AN NGV CONVERSION

Every NGV conversion has a number of major elements which must be installed skillfully and in accordance with regulations to avoid problems:

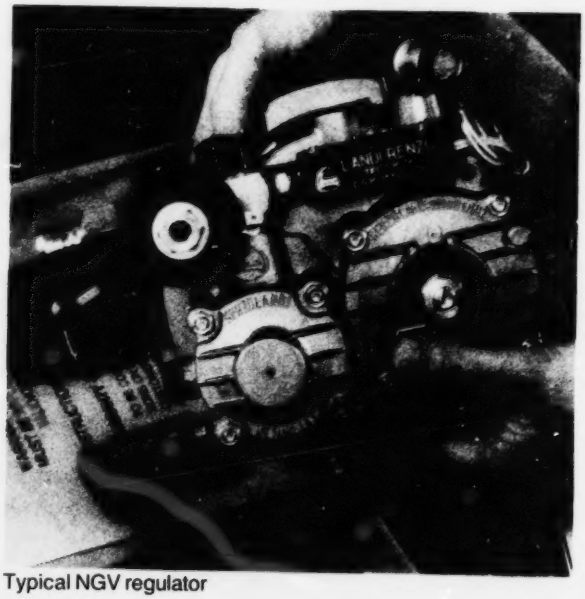
1. the fuel cylinders to store the NGV, including a pressure relief device;
2. a fuel selector switch to permit the selection of NGV or gasoline;
3. ignition system adjustment;
4. an air-gas mixer and carburetor combination suitable for dual-fuel use;
5. an automatic shutoff valve to cut off fuel to the engine when it is not running;
6. a pressure regulator to reduce the pressure of the NGV for supply to the carburetor;
7. supply lines which connect the components;
8. a refuelling connection to receive the probe of the refuelling hose;
9. a master shutoff valve;
10. a fuel gauge to indicate the remaining fuel quantity.

Steel (foreground) and aluminum (background) cylinders



Cylinders may be mounted under the vehicle if ground clearance requirements are met

Typical trunk installation of a cylinder



Typical NGV regulator

Fuel Cylinders

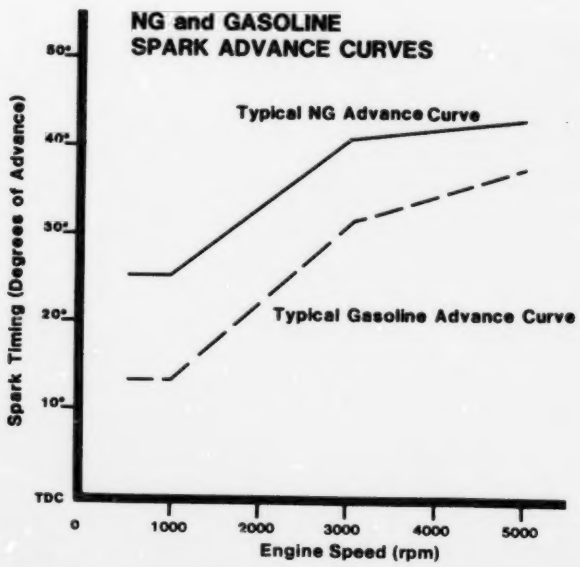
The fuel cylinders are constructed of steel or fibre-wrapped aluminum and are approved by the Canadian Transport Commission and the Pressure Vessels Branch of the Ministry of Consumer and Commercial Relations. An aluminum cylinder is about 75% of the weight of a high-tensile steel cylinder of comparable capacity and is more expensive. Weight is an important operational consideration. With a light automobile and a heavy cylinder, it may be necessary to install a stiffer suspension or add an additional leaf or spring.

Another important factor is range. A popular steel cylinder size is 60 L, which holds a quantity of NGV equivalent to about 17 L of gasoline. A normal conversion consists of two fuel cylinders. If the conversion contained two 60 L tanks and the vehicle had a fuel efficiency of 15 L/100 km on gasoline, this NGV storage capacity would provide a range of 225 km on natural gas. Normal vehicle range requirements, as well as the amount of vehicle space that can be dedicated to NGV storage, should be carefully considered prior to conversion to minimize the inconvenience of vehicle refuelling.

Cylinder Location

The cylinder or cylinders must be securely fixed to be able to withstand a collision and to minimize adverse effects on the balance of the vehicle. Typically, in an automobile, the cylinder will be bolted through the trunk to the frame, with the neck of the cylinder isolated, sealed from the interior of the vehicle, and vented to the outside. In a truck, there are more options for location, and usually two or more cylinders will be mounted in the carrying com-

NGV mixer mounted within the air cleaner



NGV requires more spark advance than gasoline

partment. The necks of the cylinders may be mounted downwards through the floor to achieve the venting requirements. Mounting the cylinders underneath is sometimes possible but requires protection of the valves and piping from stones or other potential thrown objects. The location will have to be selected in accordance with road clearance regulations. Mounting NGV cylinders on the roof of a vehicle is not permitted.

Master Shutoff Valve

Every NGV system must have a master shutoff valve between the cylinders and the pressure regulator. It is often mounted under the hood and should be readily accessible and clearly marked.

Pressure Regulator

The system must have a regulator to reduce the pressure of the NGV from its storage pressure of up to 20 680 kPa (3000 psi) to close to atmospheric for supply to the carburetor. The regulator must be securely mounted and will usually be in the engine compartment.

Carburetor

It is necessary to mix NGV and air and to supply this mixture to the engine. Normally, a separate gas-air mixer is provided on top of the gasoline carburetor so that the correct gas-air mixture is fed straight through the gasoline carburetor when the vehicle is operating on NGV.

Ignition System

NGV requires more spark energy and voltage to ignite than gasoline. This is primarily because, as a dry gas, an NGV air mixture is a better insulator than a gasoline-air mixture. An NGV engine therefore requires a high-energy ignition system. The electronic systems supplied on modern vehicles normally perform well in this regard, but if the vehicle ignition system is not adequate to ignite NGV reliably, or if prolonged exposure to low temperatures is expected, a high-energy ignition system should be installed at the time of conversion.

Electronic unit to control spark advance on NG and gasoline

The octane rating of NGV is 115, in comparison with 85 to 90 for gasoline. To permit the engine to operate on each fuel, the ignition timing can be adjusted such that the spark is advanced for NGV, relative to the stock timing for gasoline. Most conversions include a dual-curve electronic ignition system which advances the normal gasoline spark timing when operating on NGV.

Refuelling probe fits in filling connection

Fuel selector switch for gasoline and NGV

Refuelling Connection
The refuelling connection is of standard design to receive the probe at any NGV refuelling station. Refuelling simply consists of inserting the probe into the connector and opening the fuel flow control valve. When filling stops, the valve is shut off, and a small amount of NGV is released, to allow the withdrawal of the probe. The connection includes a check valve which seals the system after refuelling and is equipped with a dust plug to keep out foreign material.

Automatic Shutoff Valve
An automatic shutoff valve will stop the supply of NGV to the engine when it is not running.

Fuel Selector Switch
A fuel selector switch will enable the driver to choose which fuel he wishes to use. It will normally have three positions — NGV, neutral, and gasoline. When changing from gasoline to NGV, the driver will first switch from gasoline to neutral and pause there briefly. In this position, both gasoline and NGV are cut off from the carburetor, but the engine continues to run on the gasoline still in the carburetor. As the engine power begins to drop, the driver completes the switch to NGV and the gas takes over as the fuel supply.

When changing from NGV to gasoline, the switch is passed directly through the neutral position without stopping. NGV supply is cut off and gasoline flow is started. The engine will hesitate slightly as it waits for gasoline to pass from the control valve to the carburetor and then will continue, with gasoline as its fuel supply.

There are two electrically operated solenoid valves, each of which stops the flow of one fuel while the other is being supplied.

Fuel Gauge
The system will have a fuel gauge, normally on the dashboard, to indicate the volume of fuel remaining in the cylinders. Three gauge types are in common use, one which shows the fuel cylinder pressure directly in kilopascals (kPa) or pounds per square inch (psi), the second which symbolically shows the remaining fuel quantity with a row of lights, and the third which uses the gasoline fuel gauge directly. Whatever the method, the pressure will be detected somewhere in the system (normally by a transducer just upstream of the pressure regulator) and will be transmitted to the dashboard gauge electrically.

Pressure Relief
A means of pressure relief is provided on or close to the cylinders, such that in the event of a fire, where the pressure in the cylinders is rising, a disc will burst allowing a controlled release of the natural gas.

The device itself consists of a membrane backed with a fusible plug. The backing will melt at 100°C (212°F), exposing the membrane, which is manufactured so as to burst at between 28 960 and 34 470 kPa for steel cylinders (4200 to 5000 psi) and between 24 820 and 26 890 kPa for aluminum cylinders (3600 to 3900 psi). Only when the combination of both high temperature and high pressure are present will the device burst.

NG is lighter than air and, therefore, will dissipate quickly. Moreover, it is not explosive and can only form an explosive mixture with air if it forms more than 5% and less than 14% of the mixture. The relief is piped away from the cylinders to an outside point on the vehicle. In this way, the possible formation of an explosive gas-air mix is minimized.

One of three types of fuel gauges in common use.

High pressure supply line

Supply Line

The tubing used for the fuel supply line must be of strong corrosion-resistant material which can bend without fracture or significant change in cross-section so as to permit loops and curves in the line where necessary. It must be able to withstand a pressure of about 83 000 kPa (12 000 psi) and is normally made of stainless steel of 6.4 mm (1/4 in.) diameter. It must be routed from the cylinders to the engine compartment as directly as possible, without passing through the passenger compartment. It must be kept clear of the catalytic converter or any other part of the exhaust system or engine manifold which might become very hot, and it should be attached to the frame where possible.

Testing and Approval

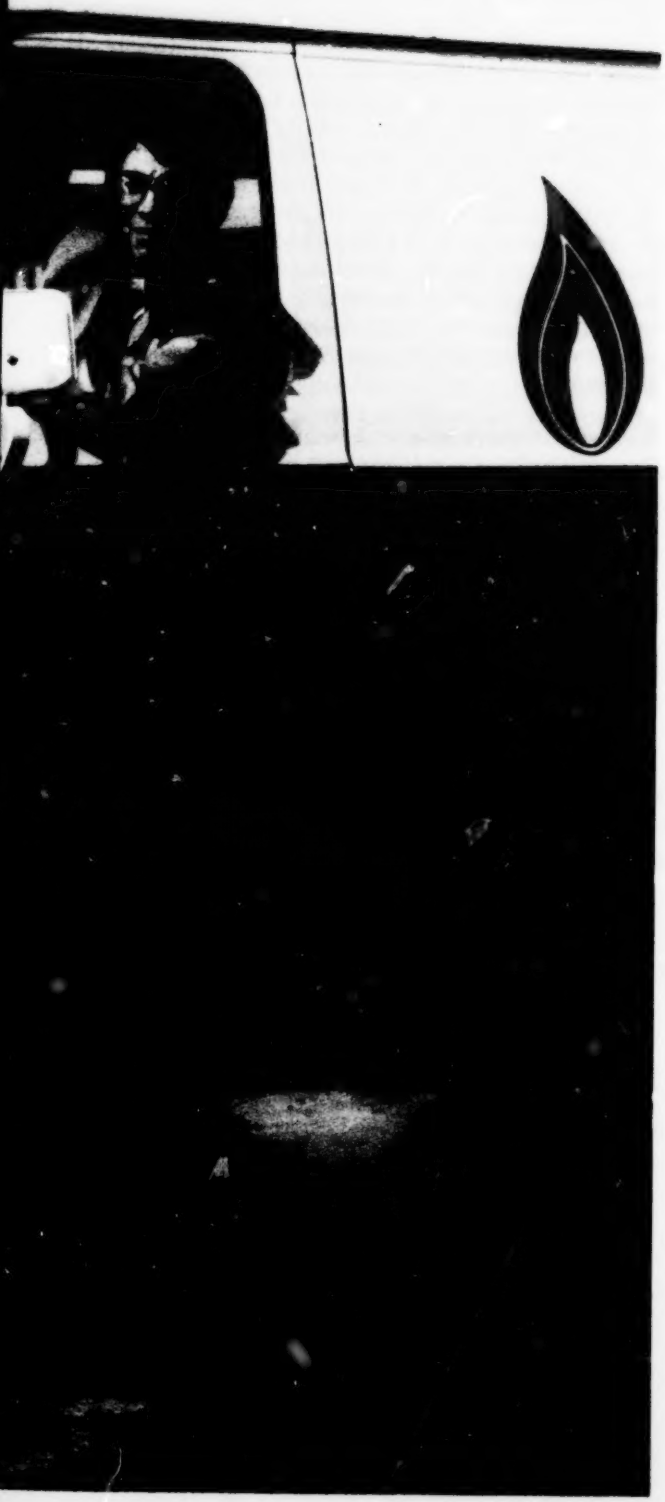
A properly tuned installation will require as a minimum the use of an exhaust gas analyser and, preferably, a chassis dynamometer. Sampling the exhaust emissions will ensure that the correct air-fuel mixture is obtained both at idle and under load (with the dynamometer). In addition, the dynamometer provides the opportunity to tune the installation to produce maximum power output on both fuels.

After the system has been installed, it must be tested. All tubing will be pressure tested and leaks corrected. A label will be attached to certify that it has been installed by a contractor registered by the Fuels Safety Branch of the Ministry of Consumer and Commercial Relations. However, drivers should be watchful for any leaks. Leaks can be detected by the presence of the strong odorant in the fuel. If necessary, return the vehicle to have the leaking joints sealed.

A vehicle involved in an accident which damages any part of the NGV fuel system will require retesting after repair.

Engine tuning on a dynamometer improves fuel efficiency and power output on both fuels

Steel fuel cylinders will require re-inspection after five years (three years for aluminum cylinders). At this time, the cylinders will be tested hydrostatically to a pressure of 34 470 kPa (5000 psi), which they must sustain with minimal distortion. At that time, a visual inspection will also be made for corrosion or any other indications of potential weakness. Fuel cylinders can last up to 20 years.



ROUTINE OPERATION OF NGV VEHICLES

Operating an NGV vehicle will be a new experience for most drivers. While it is very similar to driving a gasoline-powered vehicle, there are some differences in how an NGV vehicle should be driven and maintained.

Driveability

In normal temperatures, a well-converted NGV vehicle will have good driveability and response to changing speeds and loads. The response to the accelerator is rapid because the fuel is supplied directly in gaseous form, and the engine will run smoothly. The accelerator response is so smooth that the operator may have the impression that the vehicle has more power on NGV than on gasoline.

The smooth running of NGV is an advantage of the fuel, but it may also deceive the operator into thinking that he does not have to observe the same type of care as he does with a gasoline-powered engine. Gasoline engines may be started and driven straight away, but the driver should not use full throttle until the engine has warmed up and the lubricating oil is acting effectively. The same is true for an NGV-powered engine, although engine hesitation which occurs when driving a cold gasoline engine will not occur with an NGV vehicle.

Low Temperature Operations
Canadian winter conditions pose significant problems for all motor vehicles. Systems which prove satisfactory in the United States and Europe often demonstrate inadequacies in Canada. NGV equipment has been primarily developed in Europe and the United States, and it is not surprising that extra measures are required for low temperature operations.

The major relevant characteristic of NGV (in comparison with gasoline under these conditions) is that it requires a higher spark energy to ignite. Many NGV conversion companies will install a high-energy ignition kit even in moderate climates, and this will be even more of an advantage if cold temperatures of −15°C or lower are expected. A battery warmer may also be an advantage under these conditions. A block heater will offer the same benefit for NGV as it does vehicles powered by gasoline. A light-weight multigrade engine oil, again as with gasoline, will ensure early lubrication in cold weather conditions.

Once it has ignited, NGV has advantages over gasoline in that its cold temperature performance is equal to that at more moderate temperatures, whereas gasoline performance is significantly poorer in cold weather. NG's fuel efficiency is equally good at all temperatures and its carbon monoxide and hydrocarbon emissions are low at all ambient temperatures. NG is gaseous to −180°C and is therefore immune to any weather, however cold. Gasoline, however, is provided in the form of droplets which have to vaporize to permit combustion. Until the engine warms up there is insufficient heat to vaporize the gasoline and ignition is accomplished by reducing the air intake. However, this action increases the emissions of unburnt hydrocarbons, causes a washdown of the lubricating oil from the cylinder walls and oil dilution, and reduces fuel efficiency.

Fuel Security
Running out of fuel on the road is inconvenient no matter what fuel you are using. However, your vehicle will now be supplied with two fuels — gasoline and NGV — so that if you exhaust your NGV fuel supply you may switch to gasoline and continue to the nearest NGV refuelling station. As the network of NGV stations in Ontario expands, it will become easier to keep NGV cylinders refuelled and the need to switch to gasoline on occasion will be reduced accordingly.

Lubricating Oil
Since NGV leaves no lead, varnish, or carbon deposits, some NGV supporters have suggested that lubricating oil should last longer than with gasoline and the interval between oil changes could therefore be increased. This is not recommended. Oil will still gradually thicken, additives and inhibitors will break down, and the oil will become contaminated by combustion residues when gasoline is used. Although the oil may appear clear, it may no longer be performing its function. It would be false economy to risk engine wear to save the cost of an oil change.

Gasket and Valve Seat Lubrication
Because NGV is a dry gas and has no lubricating properties, the gaskets of some carburetors can dry out, causing gasoline leakage problems, and the exhaust valves and valve seats of some engines can wear prematurely. For many carburetors, none of the gaskets present a problem. If, however, a problem with leakage does develop, the solution is to use gasoline from time to time to perform this lubrication function.

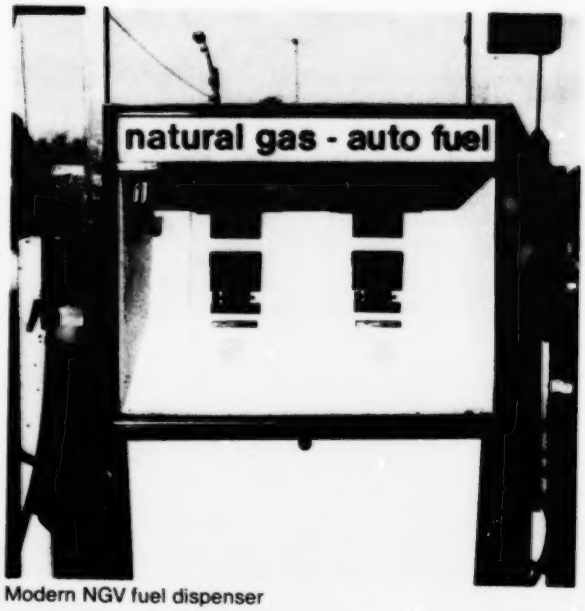
Valves and valve seat wear should not be a problem for any vehicle with a light-duty cycle, such as a standard automobile. Even if the vehicle has a heavy-duty cycle, it may not be a problem if the valves and valve seats are of hardened material. This will be so if the engine has aluminum cylinder heads, since the valve seats cannot be made of aluminum and a hardened material is used in its place. However, there is a potential problem for a heavy-duty vehicle having an engine with cast-iron cylinder heads and designed to operate on leaded gasoline. The dry non-lubricating property of NGV will permit the normally unharded valve seats in such an engine to wear unless steps are taken to lubricate them by using leaded gasoline in the engine from time to time. This will deposit a lead compound between the valve and the seat, reducing the wear. If the vehicle uses unleaded gasoline, it will most likely have hardened valves and seats and, therefore, should not be a problem. For some engines, some mechanics recommend disabling the valve rotator mechanism at the time of conversion, to minimize seat wear by preventing rotational wear as the valve seats. The requirements for vehicles in this respect should be discussed with a licensed mechanic who is trained for NGV conversions.

Spark Plug Life

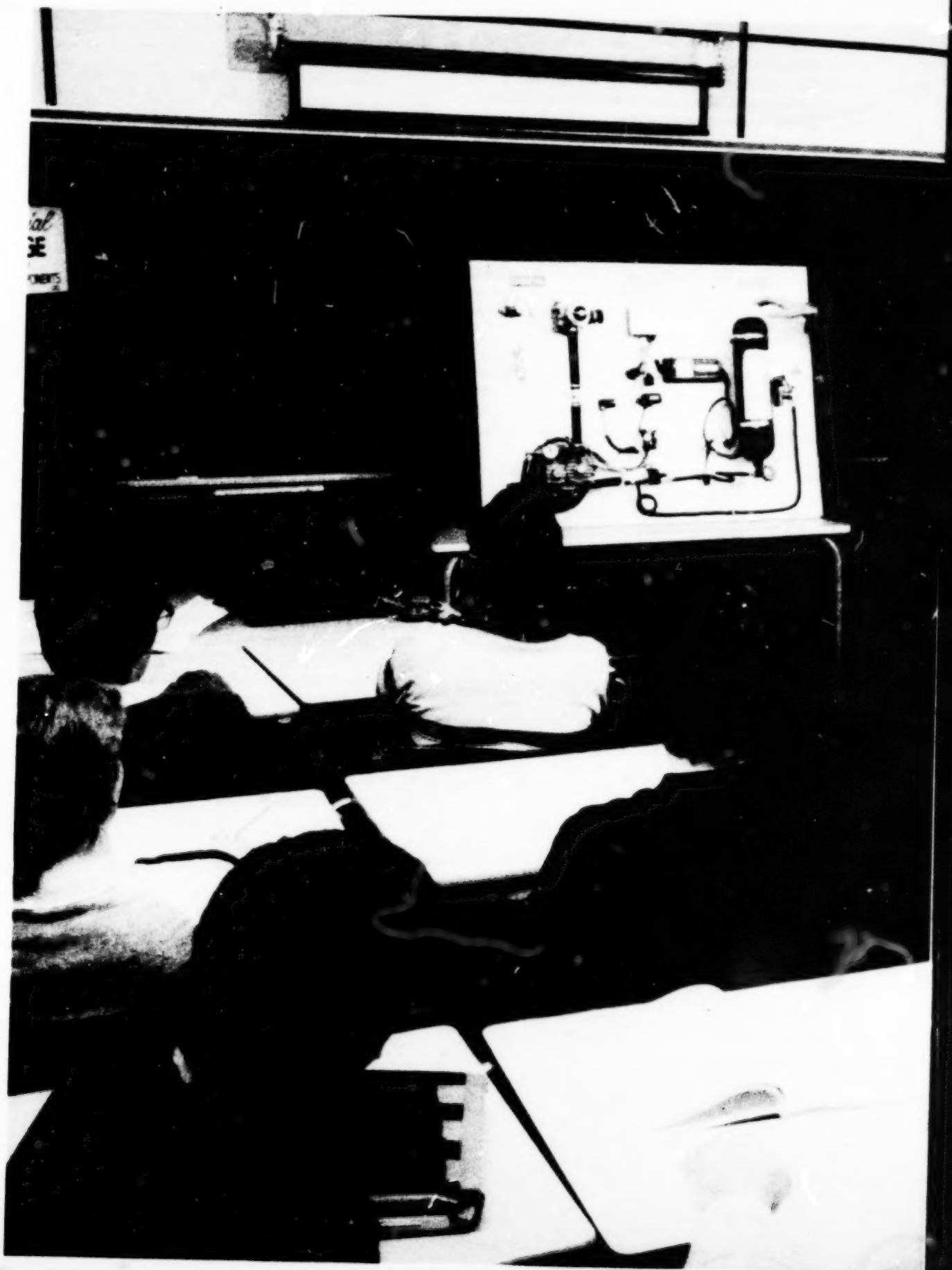
The absence of carbon and lead salts common with leaded gasoline means that spark plugs will last longer with NGV usage than with leaded gasoline.

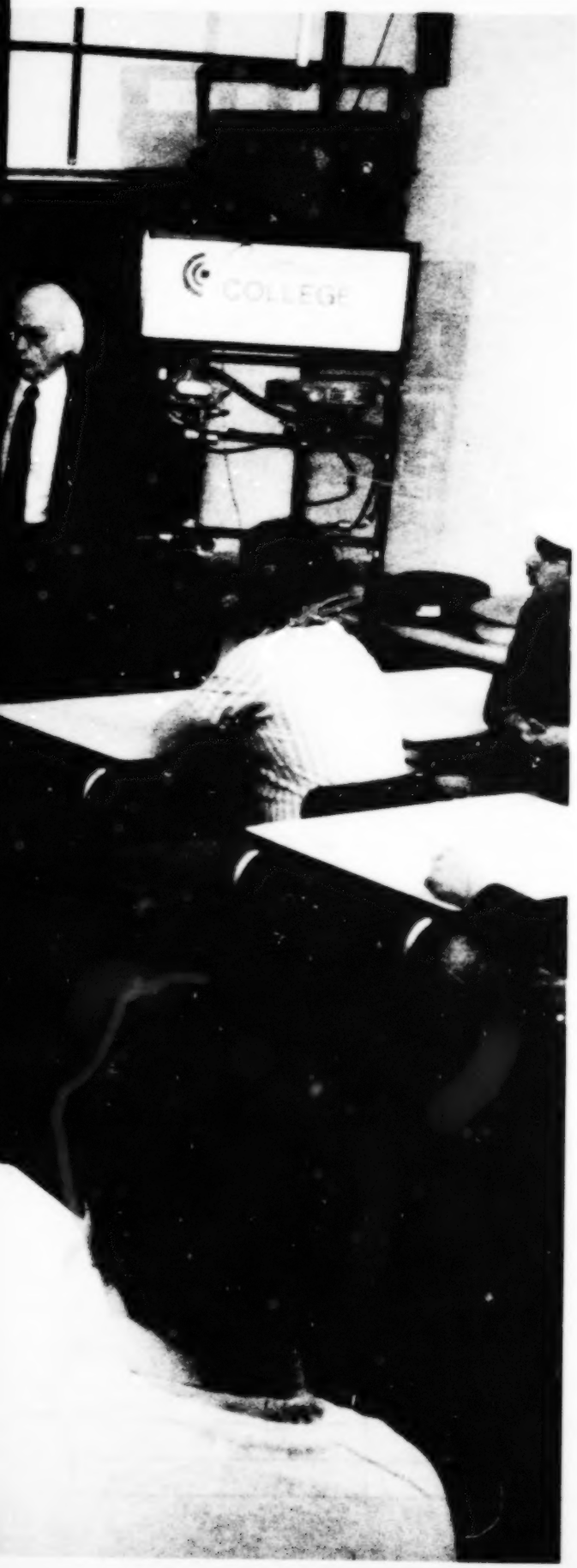
Garaging

NGV vehicles may be garaged anywhere gasoline-powered vehicles are garaged.



Modern NGV fuel dispenser





FLEET MANAGEMENT

Converting a commercial fleet of vehicles provides three additional areas of interest:

- training mechanics for fleet operations,
- technical advice and assistance from suppliers, and
- training and monitoring drivers.

Training Mechanics for Fleet Operations

Whether fleet owners choose to service their own fleets or have an outside contractor perform the required maintenance will depend on the size of their fleets and the nature of maintenance activities. If owners decide to maintain their own vehicles, they should ensure that an appropriately trained mechanic is assigned (one who has obtained an NGV conversion certificate) to a particular service assignment and that this mechanic can communicate with the driver of the vehicle.

In some companies, maintenance men have to be assigned to jobs in order of seniority or some other criterion, and this may prevent a mechanic familiar with NGV or the specific vehicle type being assigned to a specific maintenance assignment. Such flexibility should be negotiated before committing to the undertaking of the maintenance function. Similarly, if a driver merely reports that a vehicle will not start under certain conditions but is not available to describe the problem more specifically to a mechanic at a separate location, there may be high labour costs due to poor communication.

Particularly in the early days, flexibility in assigning staff who have dealt with a particular problem before and easy communication between maintenance and operations personnel is essential.

It is more important to have a mechanic's skills than a converter's for maintaining NGV vehicles. Therefore, for maintenance purposes, it is advisable to select maintenance mechanics and let them attend a course for NGV conversions at a community college or with a supplier. These mechanics will be able to participate in the conversion of vehicles after attending the course.

Technical Advice and Assistance

The best place for mechanics to look for assistance in dealing with a particular problem is probably from the supplier of conversion equipment. These companies have met most of the problems which can occur and are best suited to offer advice on a solution. Potential suppliers should be questioned about their services in this area, including what technical resources they have available if required.

Training and Monitoring Drivers

Driver training requirements include showing drivers how to refuel, how to change from one fuel to another, where the master shutoff is located, and how to drive effectively in each mode. It is important to work with drivers to ensure the success of the conversion program, so that all future problems with the vehicle won't be blamed on the new fuel.

For each vehicle, you may wish to consider instituting a record to monitor current and annual utilization of each fuel. Such a record should be available to the driver and to his supervisor. If NGV utilization is down, problems may then be discussed between driver and supervisor. Praise for good performance can keep drivers positively motivated towards the conversion program.

VEHICLE LOG

DATE 198__	ODOMETER ___km ___mi	FUEL TYPE				COMMENTS
		NATURAL GAS		GASOLINE		
		kg	$	L	$	

REGULATIONS AND STANDARDS

Regulation of NGV vehicle conversions and refuelling stations is a provincial responsibility. National standards have been developed by the Canadian Gas Association, under the sponsorship of the Standards Council of Canada. These standards provide the basis for system and component testing and for provincial regulations.

The following national standards apply to NGV conversions and to NGV refuelling stations and are available from the Canadian Gas Association:

- CAN1-12.3-M84, *Natural Gas Vehicle (NGV) Fuel System Components*, applies to the construction and performance of NGV fuel system components providing motive power for highway vehicles.
- CAN1-B149.1-M80, *Installation Code for Natural Gas Burning Appliance and Equipment*, specifies technical and safety requirements for any natural gas installation.
- Amendment No. 1 to CAN1-B149.1M80, *Installation of Compressed Natural Gas Fuel Systems and Containers on Highway Vehicles, and Requirements for Refuelling Stations*, sets out the requirements for the installation of NGV fuel systems and containers on highway vehicles and the requirements for NGV refuelling stations. It is intended that this amendment, with some minor changes, will be adopted shortly as an Ontario regulation to be administered by the Ministry of Consumer and Commercial Relations.